

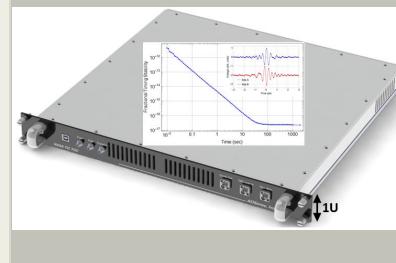
## Time Inter-Comparison Using Transportable Optical Combs, Phase II



Completed Technology Project (2017 - 2020)

## Project Introduction

AOSense proposes a free-space, two-way optical time transfer system compatible with global-scale synchronization of current-generation optical atomic clocks. In Phase I, we have demonstrated the requisite performance using existing hardware coupled with off-the-shelf control electronics. Based on our results, we have designed a fully-integrated module capable of disseminating timing signals with sub-femtosecond error from 1-10,000 s. In Phase II, we will package the device and deliver it for external testing. Our system is expected to improve ground-to-satellite synchronization a million-fold over current RF-based time transfer systems, enabling applications including clock-based geodesy, very long baseline interferometry, coherent LIDAR arrays, and tests of general relativity. The Phase I breadboard demonstration performance is consistent with a timing jitter of 3 fs @ 1s and integrates down to 700 as at 30 seconds. The corresponding fractional timing instability is  $3 \times 10^{-15}$  @ 1 second, which flickers at  $2.7 \times 10^{-17}$  out to 2000 seconds. We have identified the systematic effects that limit both short and long term stability and incorporated the improvements into the Phase II design. With these improvements, we expect a 10x improvement in both short and long terms stability of the system. In addition, we reviewed and formalized the laser driver and control electronics specifications. The initial schematic capture for critical analog sub sections was completed and a suitable FPGA/microprocessor combination was chosen to control the system and process the timing information. Based on these designs, power and size estimates were used to complete the mechanical enclosure model for the time-transfer system. For maximum flexibility in the final architecture of the overall free-space time transfer system, each frequency comb sub-unit that includes the laser and control electronics will be housed in a 1U rack mount enclosure.



Time Inter-Comparison Using Transportable Optical Combs, Phase II Briefing Chart Image

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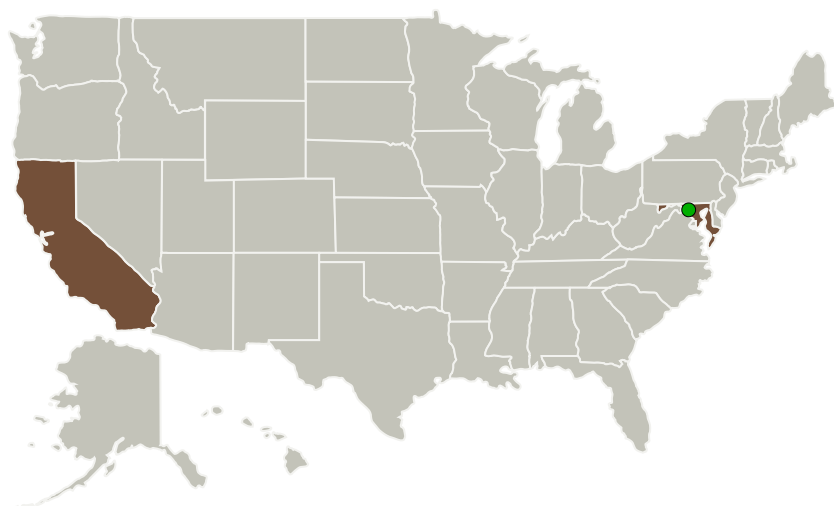
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## Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
AOSense, Inc.	Lead Organization	Industry	Sunnyvale, California
● Goddard Space Flight Center(GSFC)	Supporting Organization	NASA Center	Greenbelt, Maryland

## Primary U.S. Work Locations

California	Maryland
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## Project Transitions

**May 2017:** Project Start**February 2020:** Closed out**Closeout Documentation:**

- Final Summary Chart(<https://techport.nasa.gov/file/140657>)

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Organization:**

AOSense, Inc.

**Responsible Program:**

Small Business Innovation Research/Small Business Tech Transfer

## Project Management

**Program Director:**

Jason L Kessler

**Program Manager:**

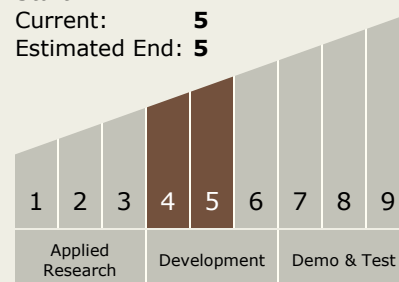
Carlos Torrez

**Principal Investigator:**

Miao Zhu

## Technology Maturity (TRL)

Start: **4**  
 Current: **5**  
 Estimated End: **5**

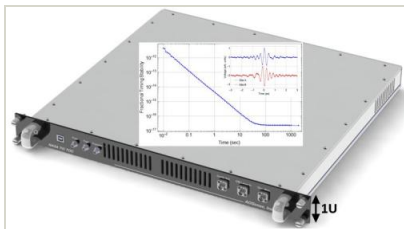


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### Images



#### Briefing Chart Image

Time Inter-Comparison Using Transportable Optical Combs, Phase II Briefing Chart Image (<https://techport.nasa.gov/image/133659>)



#### Final Summary Chart Image

Time Inter-Comparison Using Transportable Optical Combs, Phase II (<https://techport.nasa.gov/image/131917>)

### Technology Areas

#### Primary:

- TX05 Communications, Navigation, and Orbital Debris Tracking and Characterization Systems
  - └ TX05.4 Network Provided Position, Navigation, and Timing
  - └ TX05.4.1 Timekeeping and Time Distribution

### Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System